Does biogas lead to increased emissions of greenhouse gases?

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GHG emissions from agriculture

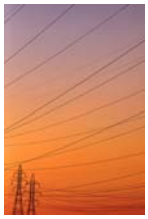
– Nitrous oxide (N_2O)

Biogas production and greenhouse gas (GHG) emissions

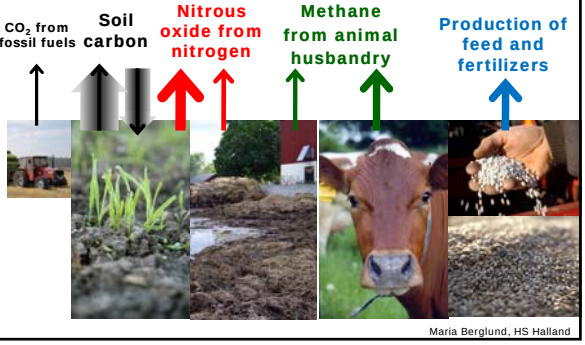
– How to compare 
and  ?

GHG emissions from agriculture

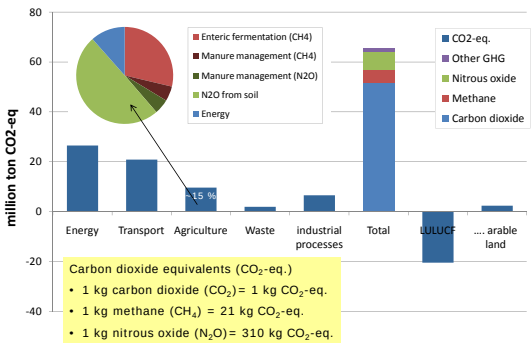
Carbon dioxide from fossil fuels


GHG emissions from agriculture



GHG emissions in Sweden, 2007

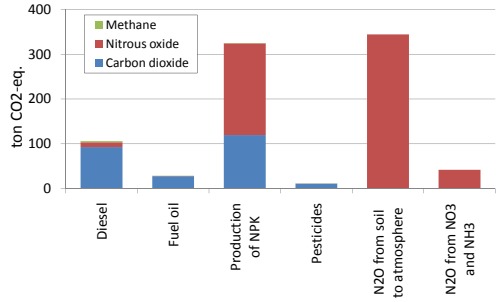


Carbon dioxide equivalents (CO_2-eq.)
- 1 kg carbon dioxide (CO_2)= 1 kg CO_2-eq.
- 1 kg methane (CH_4) = 21 kg CO_2-eq.
- 1 kg nitrous oxide (N_2O)= 310 kg CO_2-eq.

(Swedish EPA. 2009. National inventory report 2009 Sweden.)

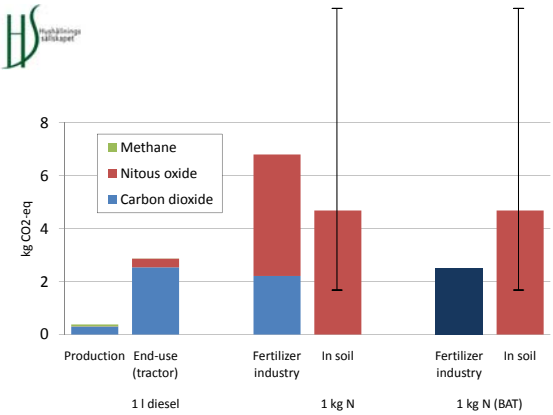
Crop production

- 278 hectare: winter wheat, barley, rapeseed, sugar beets, peas



If soil carbon content ±100 kg C/ha → ±130 ton CO_2

JOKER-projektet
www.hush.se/halland (Miljö, energi och klimat)



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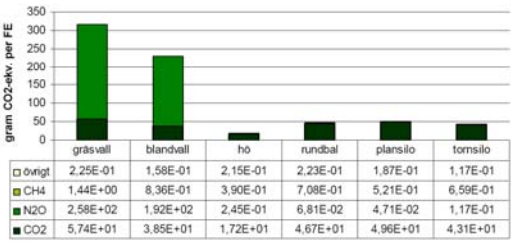
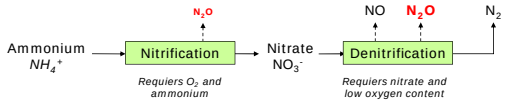
GHG emissions from cultivation and storage of grass or clover grass



	gräsvall	blandvall	hö	rundbal	plansilo	tornsilo
övrigt	2,25E-01	1,58E-01	2,15E-01	2,23E-01	1,87E-01	1,17E-01
CH4	1,44E+00	8,36E-01	3,90E-01	7,08E-01	5,21E-01	6,59E-01
N2O	2,58E+02	1,92E+02	2,45E-01	6,81E-02	4,71E-02	1,17E-01
CO2	5,74E+01	3,85E+01	1,72E+01	4,67E+01	4,96E+01	4,31E+01

(SIK report 772)

N_2O is formed from nitrogen



Higher risk of N_2O emissions if the soil / manure has:
High nitrogen content *AND*
Low oxygen level *AND*
High content of easily degradable organic matter

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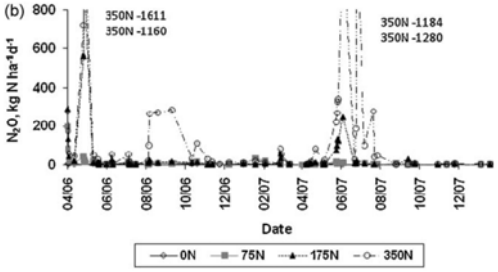

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How to estimate N_2O emissions from soil?

- **Field measuments** – costly, tricky
- **IPCC guidelines, Tier 1**

  N_2O emissions = EF*(N_{input} + N_{losses})

  Where EF = emission factor

  e.g. EF=1 % (0,3-3 %) of N additions

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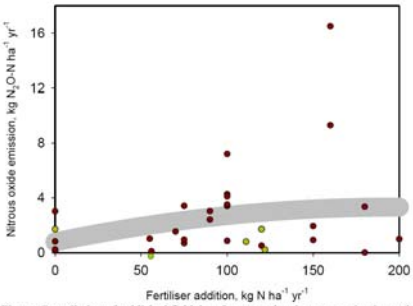

Figure. Compilation of published field data from cereal and rape cropping in north Europe and America, with a "natural" emission subtracted. Unfertilised grasslands are taken for natural. Green dots are marking out field data obtained in Sweden. Grey area show average and standard error.

Swedish energy agency. 2009.

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- **Process-based models (DNDC, Daycent, Coup)**
- **Default values** (kg N_2O/hectare)**?!**

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Suggested default values

Land	Emissions of nitrous oxide (kg N_2O-N/ha)	(kg CO_2-eq/ha)
Arable land, fertilised	3	1 400
Arable land, unfertilised	1±0,1	470±50
Grassland	0,3±0,1	140±50
Arable land, organic soil	8	3 700

(Swedish energy agency, 2009; IPCC, 2006)

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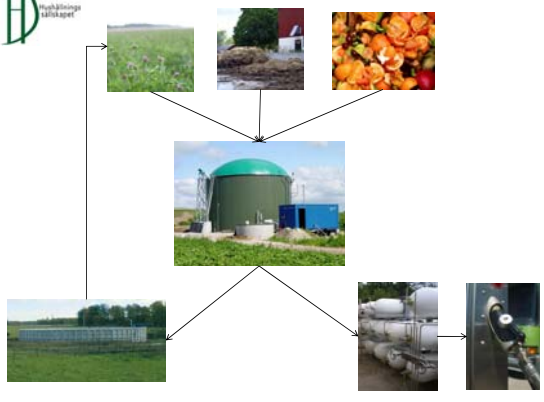
Biogas production and GHG emissions



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Raw materials

Crops

+ Improved crop sequence, N fixation, organic fertilizer
- Cultivation (use of energy, NPK, N_2O from soil)

Manure

+ Reduced emissions of CH_4 and N_2O
- Transport

Organic waste

+ Make use of plant nutrients
- More heat if combusted

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Production and use of biogas

- **Biogas production**
  + Renewable energy carrier
  - Use of energy (heat ~10%, electricity ~5% of the biogas produced)
  Losses of CH_4 (?%)

- **Upgrading and end-use**
  + Replace fossil fuel(?)
  - Losses of CH_4 (<2%?)

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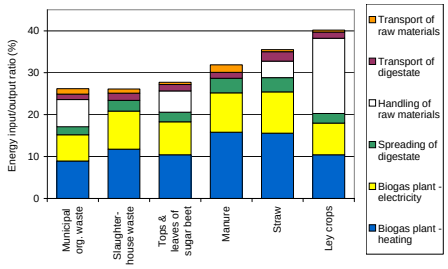
Energy efficiency in the production of biogas



$$\text{Energy input/output ratio (\%)} = \frac{\text{Total energy input}}{\text{Energy content in the biogas produced}}$$

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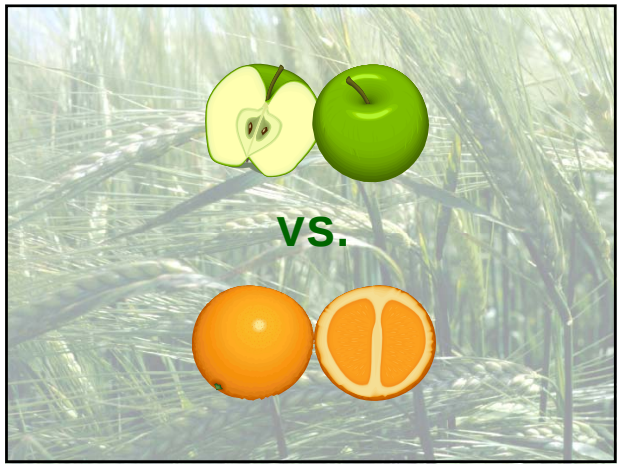

Biogas production

Reference scenario

- **Alternative management of raw materials or resources**
- **Same output (i.e. MJ energy carriers and kg fertilizer)**
- **Need for supplement production (e.g food or fodder)?**

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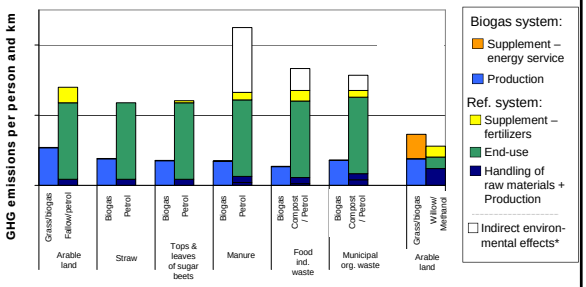
GHG emissions, light-duty vehicles



Börjesson & Berglund. 2006. *Biomass and Bioenergy. 30:254-266*

* Differences between the biogas and reference system concerning loss of methane due to varying handling of the raw materials and arable land

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1 ton (dry matter) of liquid pig manure

- Conventional storage: 24 kg CH_4 = 500 kg CO_2-eq
- Biogas production: 7 GJ biogas (=130 kg CH_4), replaces ~ 200 l petrol (600 kg CO_2-eq)

1 hectare arable land

- 7 ton (dry matter) clover grass silage = 70 GJ biogas, replaces ~2 m^3 petrol (6 ton CO_2-eq)
- GHG emission from cultivation (275 kg CO_2-eq/ton d.m.) = 1,9 ton CO_2-eq (assuming 2 kg N_2O-N/ha).
  If +4 kg N_2O-N/ha → +1,9 ton CO_2-eq/ha

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Conclusions

- **Emissions of N_2O**
  - **Large share of CF of agriculture**
  - **Hard to predict and measure**
- **Zero emissions are not relevant**
  - **Impossible to eliminate all emissions of N_2O and CH_4 from biological processes**
  - **There is always a reference scenario**
- **Biogas production has the potential to reduce GHG emissions significantly**

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